BJSM Online First, published on February 16, 2013 as 10.1136/bjsports-2012-091898

Batting head injury in professional cricket: a systematic video analysis of helmet safety characteristics

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Received 15 October 2012
Revised 20 January 2013
Accepted 26 January 2013

ABSTRACT

Background Batters in cricket are continuing to sustain head and facial injuries despite wearing protective helmets.

Objective To gain an understanding of the types and mechanisms of head injuries sustained by batters wearing a helmet.

Methods Injury type, location and mechanism were categorised via analysis of 35 videos of National or International cricketers sustaining a head injury while batting.

Results 53% of the injuries occurred following ball impact to either the helmet faceguard and peak, or the faceguard alone. Ten injuries (29%) resulted from the ball penetrating the gap between the helmet peak and faceguard. 29% of the injuries involved the ball contacting the face following penetration of the gap between the helmet peak and faceguard. Fractures, lacerations and contusions were the most common injuries associated with face or faceguard impacts while concussion was more commonly associated with impacts to the side or rear of the helmet shell. Many of the injuries described resulted in prolonged or permanent absence from cricket.

Conclusions Significant head and facial injuries occur in cricket batters despite wearing of helmets. Cricket helmet design and associated National and International Safety Standards should be improved to provide increased protection against head injury related to ball impact to the faceguard and shell of the helmet.

INTRODUCTION

Cricket is a sport played with a hard ball delivered at high speeds by bowlers who sometimes aim directly at the batter. The potential for injury is well recognised.[1] Batting helmets in cricket are designed to protect against impact from the ball, which can be bowled towards the batter from a distance of 20 m at speeds exceeding 145 km/h. Two primary components generally make up the helmet; the helmet shell and a detachable faceguard usually in the form of a metal 'grill'. Helmets have now become a universally accepted protective item for the modern professional batter and they rarely take the field without wearing one. Further, in the UK it is compulsory for cricketers under 18 years of age to wear a helmet while batting.

Owing to a lack of coordinated international cricket injury surveillance[2] the incidence and prevalence of head injuries sustained by batters, and therefore effectiveness of helmets, remains relatively unknown. Nevertheless, the England and Wales Cricket Board (ECB) injury surveillance programme has documented a number of helmet-related facial and head injuries. Furthermore, in recent years, there have been a considerable number of high-profile examples of international and first-class professional batters who have suffered serious head and facial injuries while wearing a helmet. This raises the question as to whether batting helmets are of sufficient standard to prevent, or minimise the severity of these types of injuries.

There are British/European and Australian/New Zealand standards in place for cricket helmets; however, they were published and remain unrevised since 1998 and 1997, respectively. In the only study of its kind, McIntosh and Janda[3] published 'Evaluation of cricket helmet performance and comparison with baseball and ice hockey helmets' in which drop and projectile impact tests were conducted on a variety of cricket, baseball and ice hockey helmets. The authors concluded that the projectile test method used for baseball helmets may be superior to drop tests employed within cricket helmet standards, and that cricket helmet performance was not satisfactory at realistic impact speeds.

A recent sporting helmet review paper commented that although many sports helmets have been shown to be effective in preventing moderate to severe traumatic brain injury, questions were raised regarding the robustness and appropriateness of cricket helmet evaluation procedures, particularly with regard to protection against facial injuries.[4] Thus, there appears to be a need to clarify the nature of potential cricket helmet failures.

Video analysis of sports head injury mechanisms has been used to good effect in at least two recent papers. Caswell and colleagues[5] classified the mechanisms and game characteristics of 14 head injuries in high-school girls' lacrosse and Athiviraham and coworkers[6] analysed the Major League Baseball video footage to investigate the location of the ball to batting helmet impacts in relation to concussive injury incidence and severity. The aim of this project is to gain a more thorough appreciation of the most vulnerable areas of cricket helmets by analysing high-quality video footage of a collection of cases of batters injured by being struck on the head while wearing a helmet. This information is vital to inform improvement of cricket helmet design and associated safety testing standards.

METHODS

Data collection

The cases analysed in this study were taken from an expanding database of over 50 batting

To cite: Ranson C, Peirce N, Young M. *Br J Sports Med* Published Online First: [*please include* Day Month Year] doi:10.1136/bjsports-2012-091898

helmet-related injuries collected by the authors as part of a wider International Cricket Council (ICC) project aimed at improving batting helmet safety standards. The database emanated from a series of helmet-related injuries documented in the 2008 ECB injury surveillance report. Further examples were added from a variety of sources including the ongoing ECB injury surveillance programme, canvassing of the medical staff of all ICC full test playing nations, internet searches using keyword combinations such as cricket–batting–helmet–head–injury, injury incidence reporting by the ECB performance analysis staff when coding match footage, and examples provided by ICC umpires and members of the international cricket community, who have been asked to report potentially relevant cases to the ICC Medical Committee.

ICC and ECB footage archives were then searched to retrieve any available video clips of injuries held in the database. Thirty-five video clips of international- or national-level professional batters injured by being struck by the ball on the helmet, face, head or neck while wearing a helmet were subsequently analysed. To be included in the analysis, clips were required to meet the following criteria:

- The site of impact of the ball on the batter's helmet shell, faceguard, neck, face or head must have been clearly visible.
- Footage must have been from an international or first-class/list A match or practice session that took place after January 1, 2002.
- The bowler and batter must have been identifiable.
- Footage was of sufficient duration to determine whether the batter needed immediate medical attention, and whether they were able to continue to bat without having to leave the field 'retired hurt'.
- The researchers must have had knowledge that an injury had been sustained and were able to obtain details such as the injury diagnoses, type, location, management and sequelae, via either first-hand involvement with the case or via direct communication with the injured player or the responsible team medical staff.
- The broad injury details and diagnosis, for example, concussion, laceration, fracture, contusion, must have been available via public domain reporting of the injury details.

An analysis template was then developed using an electronic spreadsheet that allowed recording of the standardised categorical data enlisted in table 1.

Categorisation of each element was made by each of the three researchers. When differences occurred, the clip in question was viewed together by all the three researchers with categorisation agreed upon by consensus.

Data analysis

Descriptive data pertaining to the categories described above were obtained via the electronic spreadsheet's analysis features.

RESULTS

The details of 35 batting helmet-related injuries sustained between 2003 and 2012 were recorded. The locations of the impacts and types of resultant injuries are shown in figure 1. Eighteen injuries (52% of the sample) occurred following the ball impact to either the helmet faceguard and peak (nine injuries, 26%), or the faceguard alone (nine injuries, 26%) (table 2). Ten injuries (29%) resulted from the ball penetrating the gap between the helmet peak and faceguard, four (11%) of these occurred when the ball was able to penetrate the gap between the peak and the faceguard without touching either part of the

Table 1 Categorical data collected for each injury

Category	Description
1	The date, type and location of the match or training
2	Whether the batter and bowler were left- or right-handed
3	The type of bowler (fast, medium-fast or slow)*
4	The area of the ball contact with the helmet shell, faceguard, neck, face or head
5	Whether there was a ball contact (direct or indirect):
	(a) Only with the helmet shell or faceguard
	(b) With the helmet shell or faceguard and the face, neck or head
	(c) Only with the face, neck or head
6	Whether an injury was immediately obvious
7	The site of any injury (part of skull, face, mandible, eye, mouth or neck)
8	The broad diagnosis of any primary or secondary injury
9	Whether the batter was able to continue batting without having to 'retire hurt'
10	The helmet manufacturer and nature of any visible helmet damage

*Fast and medium-fast bowlers were classified as such if the usual positioning of the wicket keeper was to stand back to their bowling. For slow bowlers, the wicket keeper was known to normally stand-up to the stumps. Fast bowlers were categorised as such if they were known to regularly bowl at speeds exceeding 135km/h.

helmet, that is, the gap was wider than the ball width. The other six (17%) occurred when the ball penetrated the peak and/or faceguard onto the nose, orbit or maxilla, despite the gap being set to less than the ball width.

The primary injury types are shown in table 3 with fracture (10 injuries, 29%) being the most common, followed by concussion (eight injuries, 23%) laceration and contusion, each contributing seven injuries (20%). The fracture locations were confined to the face and mandible (table 4), whereas the concussion injuries resulted from impacts to the temporal or occipital regions. Primary laceration and contusion injuries were evenly spread over the face and side of the head. While these were the primary injury types, many also had concurrent injuries, for example, fractures with lacerations, concussion with contusions and/or lacerations.

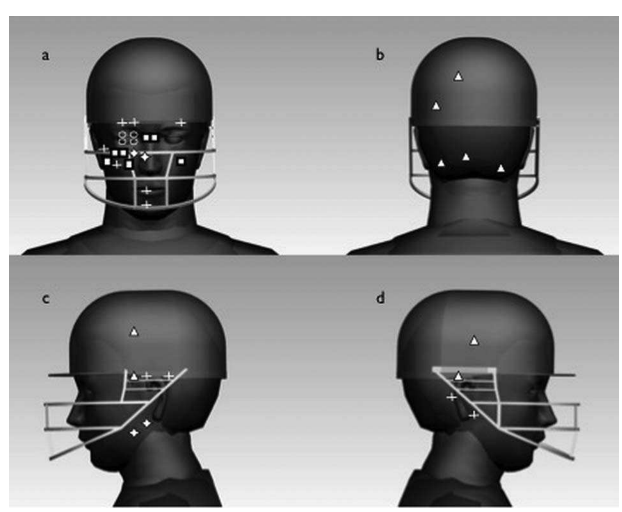

Figure 1 Impact locations and primary injury types (A) face, (B) back of head, (C) non-dominant side of the head, (D) dominant side of the head. Injury symbols; triangle—concussion, cross—laceration, star—haematoma, circle—eye, square—fracture.

Table 2 The number and percentage of injuries associated with each area of helmet ball impact

Area of impact	Injuries	% Injuries
Faceguard	9	26
Peak and faceguard	9	26
Back of shell	6	17
Temple-protector	5	14
Through peak-faceguard gap	4	11
Occiput/neck—no helmet contact	2	6
Total	35	100

In 20 cases (56%) the batters were unable to continue, that is, they 'retired hurt', with 10 fractures and 5 lacerations accounting for the majority. In several of the examples where the batter did continue it is known that, owing to the injury, they then missed cricket within the same or subsequent matches. Five injuries (14%) required extensive surgical treatment, two to repair combined orbit and maxillary fractures, one to fix unstable maxillary fractures (figure 2), another required restorative dental surgery and one of the mandibular fractures was internally fixated. All of these resulted in significant time out of the game and contributed to the retirement of at least three of these batters owing to sequelae such as ongoing visual disturbances and loss of confidence facing high-speed or short-pitched deliveries.

Thirty-four of the 35 injuries (97%) occurred when the ball impacted the helmet and/or head without first contacting any other part of the batsman or the bat, that is, they were direct impacts. The fast bowlers delivered the ball during 32 (91%) of the injury occurrences, with two (6%) and one (3%) associated with medium-fast and slow bowlers, respectively. Interestingly, two of the fastest bowlers were associated with four injuries each, accounting for 23% of the injuries in this sample.

Five different brands of helmets were worn when the injuries occurred, although the majority (29 injuries, 83%) happened when wearing two brands that accounted for 51.5% and 31.5%, respectively.

DISCUSSION

The aim of this study was to gain a thorough appreciation of the most vulnerable areas of cricket helmets by analysing the video footage of 35 cases whereby professional batters sustained head injuries while wearing a helmet. Although concerns about cricket helmet safety standards have been raised previously,[3 4] this is the first paper to document the mechanism and nature of batting helmet-related injuries, with several severe enough to result in prolonged or permanent absence from cricket.

Table 3 The number and percentage of each primary injury type

Type of injury	Injuries	% Injuries
Fracture	10	29
Concussion	8	23
Laceration	7	20
Contusion	7	20
Eye damage	2	6
Dental damage	1	3
Total	35	

Table 4 Fracture injury location

Fracture location	Injuries
Mandible	3
Orbit and nose	2
Orbit	2
Nose	2
Maxilla	1
Total	10

The results highlight some areas of particular concern including the number and severity of injuries occurring after the ball impact with the helmet faceguard and/or peak of the helmet. Two central faceguard impacts resulted in two particularly severe cases of facial fracture, while the faceguard impacting the face resulted in several facial laceration and contusion injuries. This ability of the faceguard to be forcefully pushed onto the face and mouth indicates that some faceguards are insufficiently strong, and/or inadequately designed or fixed.

Equally concerning are the ten cases where the ball was able to penetrate the gap between the helmet peak and faceguard, often resulting in orbital, nose and maxilla fracture, laceration and contusion. The current British/European standard specification for head protectors for cricketers[7] recommends that the faceguard to peak gap be set to 55 mm or less. Senior-level cricket balls have a diameter of approximately 73 mm and it is evident that with some helmets, even when the faceguard to peak gap is set to less than the ball diameter they are still able to penetrate the gap with potential to cause serious injury. This may be partly owing to compression of the ball during impact; however, analysis of the game and preliminary laboratory video footage suggests that a bigger contributor is likely to be excessive upward flexion of the helmet peak and downward flexion of the faceguard allowing the ball to force through the gap (figure 3). Further investigation of this phenomenon via laboratory-based projectile testing is required to inform improved helmet design and production so that there is a strong resistance to the ball penetrating the faceguard to peak gap.[8]

Most, if not all, current helmets can be adjusted such that the faceguard to peak gap is greater than the ball width. The four injury examples in this paper of the ball passing unimpeded though a gap wider than ball width, causing severe injury, is evidence that this is a dangerous feature,[9] especially as research

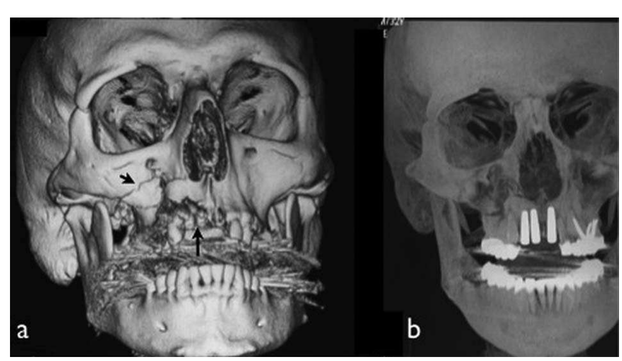

Figure 2 (A) Three-dimensional CT showing maxillary fractures (short arrow) and associated dental disruption (long arrow) following ball impact through faceguard of a batting helmet; (B) postoperative x-radiograph showing dental hardware.

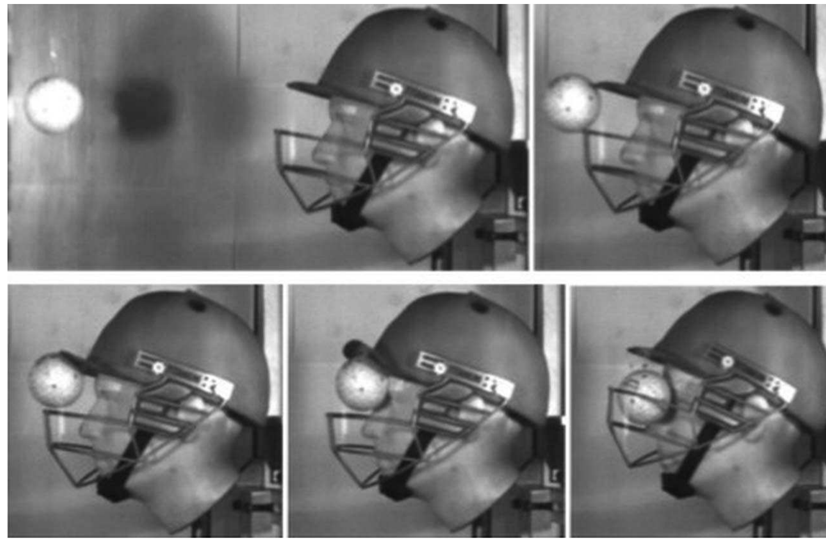

Figure 3 High-speed laboratory footage showing how a ball can force through what appears to be a narrow gap owing to the flexible peak and faceguard.

into the impact attenuation ability of faceguards in similar sports such as baseball,[10] suggests that effective faceguards can be highly protective against impact forces.

These examples indicate that ideally, the faceguard and peak should prevent the ball, or faceguard itself, contacting the face, jaw or mouth following the ball impact. This ability is a requirement of a comparable product, the baseball or softball catchers mask, whereby the standard performance specification published by the North American National Operating Committee on Standards for Athletic Equipment (NOCSAE) states that during rigorous projectile testing; no contact of the ball with the ocular region is permitted, and that only non-structural components of the headgear that are designed/intended to rest on, or come in contact with the wearer's face, are allowed to contact a delimited facial area.[11] The two most commonly attained cricket helmet standards are the 1998 British/European (BS 7928) and 1997 Australian/New Zealand (AS/NZS 4499.1-3) standards, both of which include only faceguard impact attenuation tests, and do not assess the ability of cricket helmets to resist ball contact with the face, or faceguard contact with the face.[7 12]

Another vulnerable area of current batting helmets seems to be the area over the back of the head, with concussion injuries, in particular, occurring following impacts to the helmet shell covering the posterior temporal and occipital regions. A similar video analysis study of the ball to helmet impacts in baseball also reported concussion diagnoses to be more frequent for posterior versus anterior helmet impacts.[5] Prevention might be achieved via improved shock attenuation and by extending the shell of the helmet to cover the entire occipital region. This is because in some instances the ball partially struck the helmet and partially directly struck the underlying occiput, an area of the head that does not seem to be completely assessed within the current cricket helmet standard impact attenuation test specifications.[7 12]

As also cited in the aforementioned baseball study,[5] the vast majority of injury examples in this study occurred when facing very fast bowling, which might indicate that this type of injury risk predominates within elite cricket. Therefore, an option may be to make highly protective bespoke helmets for elite players. However, the wide availability of high-speed bowling machines now used during practice sessions at all levels of the game suggest that mass market helmets should also protect against the types of injuries detailed in this paper.

There are several limitations of this study. Although a thorough search was undertaken, the sample is one of convenience and we are not able to determine the actual incidence and prevalence of injury from being struck on the head while batting in professional cricket. However, this, high-quality video database of 35 potentially preventable injuries indicates that action is required to improve the protection afforded by batting helmets. While there are examples available of cricket ball to helmet impacts that have not resulted in injury, the wide variety of helmet makes, models, materials and adjustment settings means that comparing the injury impacts to valid 'case-controls' is not possible. A further limitation is that the exact severity of injury (in terms of compromised performance, cricket time-loss and treatment required) suffered in each case was not available for all injury examples, however the primary injury type and immediate effect of the injury (whether the player could continue to bat or not) was always known, with follow-up details available in most of the cases.

Concerns regarding head injury in other sports have also led to changes in helmet use and design. In ice hockey, the emergence of a significant number of catastrophic head injuries lead to compulsory use of helmets in Sweden in 1963.[13] Subsequent improvements such as face protectors (1978)[14] and throat protectors (1987)[15] were added to helmet design in response to an increase in face, eye and dental injuries identified through injury surveillance data. Helmet improvements have also occurred in response to identified issues in sports such as baseball[16] and lacrosse.[17] The finding that the vast majority of injury examples occurred while wearing only two brands of helmet is likely to be proportional to the number of batters who wear them, however it does indicate that at the very least, improving these helmets might significantly reduce the risk of injury.

CONCLUSION

This novel analysis of a video database of 35 head injury occurrences in cricket batters indicates that some current helmets used in elite cricket do not adequately protect them against head and facial injury. The common failings appear to be, inability to resist the ball penetrating the gap between the helmet peak and faceguard, injurious impact of the faceguard onto the face following ball impact, and potentially inadequate or incomplete helmet coverage of the back of batters' heads. It is recommended that the apparently out-dated testing standards currently in use should be revised to incorporate projectile tests that preclude ball and faceguard facial contact, and rigorously assess impact attenuation particularly of the lower rear of the cricket batting helmet shell. Further research that informs improved design and material quality is also recommended. The aim being to reduce the likelihood and severity of the types of facial and orbital fractures, concussion, laceration and contusion injuries detailed in this study.

What are the new findings?

- This is the first paper to document the type and mechanism of a number of head injuries suffered by the national and international cricket batters.
- Key areas wherein helmet design might be improved have been identified.

How it might impact clinical practice in the near future?

- The results will inform helmet manufacturers along with the National and International Standards agencies to improve helmet design and safety testing procedures.
- The findings of the paper would be used to educate players and support staff as to appropriate choice, adjustment and wearing of batting helmets.

Acknowledgements The authors acknowledge the ICC and ICC Medical Committee for their support of the project. Thanks also go to project collaborators at the Loughborough Sports Technology Institute, Nikunj Velani, Dr Andy Harland and Will Sach.

Contributors All authors contributed to the conception and design of the study, the collection, analysis and interpretation of data, and to the draughting, revising and finalising of the paper's intellectual content. All authors provide final approval of the submitted version.

Competing interests None.

Patient consent Obtained.

Ethics approval All injury information was available via public domain reporting. BMJ consent forms were signed to provide consent for the use of figure 2.

Provenance and peer review Not commissioned; externally peer reviewed.

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